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An Evaluation of Sealed Idle Mixture Adjustment on 1977 Buicks

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16. ABSTRACT

This report describes the results of an EPA program conducted on 48 in-use passenger cars. Each of these vehicles was a 1977 Buick equipped with a 350 CID engine and a four barrel carburetor. Some of these engines were equipped with special carburetors which had lead plugs covering their idle mixture screws to prevent maladjustments. The purpose of this program was to gather information on current vehicles which will allow EPA to project the effectiveness of similar systems after they have been employed on future vehicles. The program included direct mail solicitation, a parking lot survey, and complete FTP testing. This work was conducted in the Detroit area and at EPA's Laboratory in Ann Arbor during the summer of 1980.

The results indicate that this technique for sealing the idle mixture screws is an effective method for preventing the adjustment of the idle mixture. Average idle emission test results for the sealed carburetor vehicles were similar to the results for untampered vehicles with conventional carburetors. Average idle emissions from vehicles with broken or missing limiter caps were substantially higher.

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An Evaluation of Sealed Idle Mixture Adjustment on 1977 Buicks

by

Karen E. Marschall

November 1980

Test and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air, Noise, and Radiation
U. S. Environmental Protection Agency

ABSTRACT

This report describes the results of an EPA program conducted on 48 in-use passenger cars. Each of these vehicles was a 1977 Buick equipped with a 350 CID engine and a four barrel carburetor. Some of these engines were equipped with special carburetors which had lead plugs covering their idle mixture screws to prevent maladjustments. The purpose of this program was to gather information on current vehicles which will allow EPA to project the effectiveness of similar systems after they have been employed on future vehicles. The program included direct mail solicitation, a parking lot survey, and complete FTP testing. This work was conducted in the Detroit area and at EPA's laboratory in Ann Arbor during the summer of 1980.

The results indicate that this technique for sealing the idle mixture screws is an effective method for preventing the adjustment of the idle mixture. Average idle emission test results for the sealed carburetor vehicles were similar to the results for untampered vehicles with conventional carburetors. Average idle emissions from vehicles with broken or missing limiter caps were substantially higher.

INTRODUCTION

Over the past several years, the results of various programs have shown the significant effect that idle mixture adjustment has on exhaust emissions as measured by the Federal Test Procedure (FTP). A major study of three hundred 1975 and 1976 passenger cars (Reference 1) concluded that carburetor maladjustment was the greatest single reason that caused vehicles to fail their standards. Once maladjusted idle mixture and speed were adjusted to manufacturers' specifications, the average HC and CO emission levels for the entire fleet were reduced by 30% and 56%, respectively. On a subset of properly tuned cars in the same study, it was found that an idle mixture adjustment performed using the classic "lean best idle" technique would double HC emissions and triple CO emissions when the vehicle was tested over the FTP.

Based on these and other findings, the EPA has published regulations which are designed to limit the range of adjustable parameters which have been found to affect emission levels. These rules begin to take effect with light-duty vehicles of the 1981 model year. The purpose of these regulations is to help ensure that in-use vehicles maintain the low level of emissions established by prototype and production vehicles from the certification process.

In anticipation of these regulations, many manufacturers have chosen to incorporate preliminary designs for limited adjustability in their current models. General Motors, for example, has employed rivets instead of screws in the attachment of the thermostatic coil cover to make choke adjustments more difficult, and have redesigned carburetors to use steel caps over recessed idle mixture screws. The adjustments are made prior to installation on the engine. This method to prevent idle mixture maladjustment is the subject of this test program.

General Motors first employed recessed screws and a capped access on a sample of 5000 Buicks during the 1977 model year. These carburetors were identical in all other aspects to standard models which were equipped with conventional plastic limiter caps. These cars were at least three years old and averaged approximately 40,000 miles at the time of the test program.

PURPOSE

The overall purpose of this project was to evaluate the relative effectiveness of this system to prevent idle mixture maladjustments. This was to be accomplished by examining three areas of interest:

1) whether the average emission test results of the vehicles with sealed carburetors (Group A) differed from the average emission test results of the vehicles with regular carburetors (Group B),

2) to compare the percentage of broken or missing limiter caps to the percentage of broken or missing lead plugs, and

3) to determine whether a non-adjustable idle mixture could cause any engine performance problems or result in owner dissatisfaction.

The information will be used for projections of overall effectiveness of such devices once they have been in widespread use for several years.

PROGRAM DESIGN

The program used two different methods to gather data. The first method involved direct contact with the vehicle by an EPA employee. This included short tests and underhood inspections and was supplemented by complete FTP testing on some vehicles. The second method was a mail survey, in which owners were asked to inspect their own vehicle and mail us the information.

Parking Lot Survey

The first step of the program was to conduct short inspections and four-speed idle tests on a small sample of both Group A and Group B vehicles. General Motors supplied the VIN's of Detroit area Buicks equipped with sealed carburetors. The R. L. Polk Company used these VIN's to supply the names and addresses of 108 owners of vehicles with sealed carburetors (Group A), plus the names and addresses of 200 owners of vehicles which were identical with the exception that they had been equipped with standard carburetors (Group B). Direct mail solicitation (Appendix A) was used to invite Buick owners from the Detroit metropolitan area to bring their vehicles to a parking lot survey held at Eastland Mall. This is a large shopping center located in Harper Woods, a suburb adjacent to Detroit. Owners who attended this survey were offered a check for ten dollars. Owners which were not able to attend the parking lot survey were invited to bring their vehicles directly to EPA's Motor Vehicle Emission Laboratory (MVEL) in Ann Arbor. These owners were offered a check for ten dollars and a full tank of fuel.

Once the owner arrived at the parking lot or at the MVEL, he was interviewed to determine the date of the last tune-up and any engine performance problems experienced with the vehicle. This information was recorded on the Vehicle Owner Questionnaire (Appendix B). A visual underhood inspection was performed to determine which category (sealed or standard) the carburetor fell into, whether the limiter caps or lead plugs had been removed or broken, and if all the emission components appeared to be in proper operating condition. A brief exhaust emissions test was performed using a portable garage-type analyzer. This test is known as the four-speed idle test and consists of measuring the concentrations of HC and CO at 1) idle speed in neutral, 2) 2500 RPM in neutral, 3) idle speed again in neutral, and 4) idle speed in drive. This information was recorded on the inspection form (Appendix C).

Laboratory Tests

From the vehicles which received short cycle tests, 16 were selected to be brought in to the MVEL for more extensive testing. Owners of vehicles which were to undergo this testing were contacted by phone. These owners were mailed a $50 United States Savings Bond, given a loaner vehicle for their use while their vehicle was being tested, and had their vehicle returned with a full tank of fuel. Vehicles were tested at a rate of two per week. The following test sequence was performed twice on each vehicle:

1) The 1975 Federal Test Procedure (exhaust emissions only).

2) The Highway Fuel Economy Test (HFET).

3) The Four-Speed Idle test.

4) The Loaded Two-Mode. This short test consists of two operating conditions. At the end of a two minute idle period, the vehicle is operated at 30 mph and at 9 actual horsepower. Immediately following sampling in this mode, the exhaust is sampled at idle with the transmission in neutral. The garage-type analyzer is used for these measurements.

Of the 32 total sequences, 1 was aborted due to engine noise and 5 were voided due to suspected exhaust leaks.

Mail Survey

In order to obtain additional information on the number of maladjusted limiter devices, owners of Detroit area Buicks which were not inspected were included in a mail survey. The only owners which were excluded in this second Detroit-area mailing were those whose letters had been returned to us as undeliverable or those who had sold their vehicle. The owners were again invited to bring their vehicles to the MVEL or to perform an inspection of their carburetor themselves. In the latter case, they were instructed to simply match the appearance of their carburetor to one of four pictures which were sent with the letter. The owner filled in his response on the enclosed reply card and returned the card to us. This allowed us to determine whether or not the limiter device had been removed. The contents of this package are attached as Appendix D. This mail survey was also extended to include approximately 200 owners from Houston and Chicago, although names and addresses were only available for owners of vehicles with sealed carburetors. These results will be addressed in a supplement to this report when comparable results are received for vehicles with regular carburetors.

RESULTS

Parking Lot Survey

A total of 308 letters were mailed to Detroit area Buick owners inviting them to our parking lot survey. Nineteen owners attended the survey. A chart giving the complete response breakdown is attached as Figure 1. In addition to these nineteen vehicles, ten more owners brought their vehicles directly to MVEL. Thus, a total of 29 venicles were given short inspections and a four-speed idle test. Fifteen of these vehicles had sealed carburetors (Group A), and fourteen had conventional carburetors (Group B). The average odometer readings for the two groups were 38,400 and 41,000, respectively. Complete results on these vehicles are attached as Appendix E. Group A's average four-speed idle emissions are lower than those for Group B. These results are listed in Table 1. Table 2 divides Group B's results into the results of those vehicles with removed limiter caps and those with intact limiter caps. The idle emissions of the vehicles with limiter caps intact are similar to Group A's idle

emissions. The idle emissions of the vehicles with broken or missing limiter caps are substantially higher than Group A's idle emissions.

Table 1
Average Emission Results from Parking Lot Survey
Four-Speed Idle Test

	N	I(N) HC (ppm)	I(N) CO (%)	2500 (N) HC (ppm)	2500 (N) CO (%)	I(N) HC (ppm)	I(N) CO (%)	I(D) HC (ppm)	I(D) CO (%)
Group A	15	121	.13	44	1.07	112	.09	59	.08
Group B	14	242	.65	79	1.06	205	.68	92	.59

Table 2 lists the average 4-speed idle emission results from Group A and from both the Group B untampered and tampered vehicles.

Table 2
Average Emission Results from Parking Lot Survey
Four-Speed Idle Test

	N	I(N) HC (ppm)	I(N) CO (%)	2500 (N) HC (ppm)	2500 (N) CO (%)	I(N) HC (ppm)	I(N) CO (%)	I(D) HC (ppm)	I(D) CO (%)
Group A	15	121	.13	44	1.07	112	.09	59	.08
Group B untampered	9	255	.15	90	.99	204	.11	76	.08
Group B tampered	5	219	1.5	60	1.19	206	1.69	121	1.52

Of the fifteen vehicles from Group A, only one lead plug appeared to be tampered. Of the fourteen vehicles from Group B, five had their limiter caps removed or broken.

The majority of the participants in the survey were satisfied with the performance of their vehicle. The sealed carburetor did not appear to cause more engine performance problems or owner dissatisfaction than the regular carburetors. Of the 29 owners, 4 from each group indicated that they were experiencing engine performance problems. The most common complaint was that of engine noise or lifter noise, given as the problem in 4 of 8 cases. A complete list of answers from the Vehicle Owner Questionnaire is attached as Appendix F.

Testing at MVEL

Complete FTP, HFET, and short cycle test results are attached as Appendix G. An indication of the condition of the emission-related components is also included. The only notable finding from the underhood inspection was the unexpectedly high failure rate of EGR valves. Figures

2-4 are bar charts comparing average FTP HC, CO and NOx emissions of Group A and Group B. Figure 5 compares the owners estimate of their fuel economy to both the EPA Mileage Guide values and the FTP and HFET fuel economy results. The average FTP emission results for Group A are higher than for Group B for HC and CO, and lower for NOx. Both the city fuel economy and the highway fuel economy are lower for Group A than for Group B. The high FTP CO results for Group A are mainly due to one vehicle. This vehicle had excessively high CO emissions, possibly from a problem in the main metering circuit or power enrichment circuit of the carburetor. When these results are excluded, Group A's average FTP results are 1.30 g/mi HC, 19.17 g/mi CO, and 3.29 g/mi NOx. These results are approximately equal to those of vehicles in Group B. Table 3 lists the average FTP emission and fuel economy results and the average HFET fuel economy results for both Group A and Group B.

Table 3
Average FTP and HFET Results from Testing at MVEL

			FTP				HFET
	N	Odom	HC (g/mi)	CO (g/mi)	NOx (g/mi)	MPG	MPG
Group A	5	47663	1.54	35.26	2.98	14.4	21.1
Group B	8	43342	1.24	20.57	3.35	14.8	22.3
1977 Federal Standards:			1.5	15	2.0	15*	22*

*EPA Mileage Guide values.

Vehicles in Group A were found to have lower average emissions than Group B for all modes of both the four-speed idle and the loaded two-mode tests. Table 4 lists the average four-speed idle and loaded two-mode emission results for Group A and Group B.

Table 4
Average Short Cycle Test Results from Testing at MVEL

	Four-Speed Idle								Loaded Two-Mode			
	I(N)		2500(N)		I(N)		I(D)		Loaded		I(N)	
	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)	HC (ppm)	CO (%)
Group A	113	.12	34	.70	116	.13	59	.17	44	.37	130	.09
Group B	142	.69	46	.81	132	1.04	117	1.03	81	.56	141	1.08

Mail Survey

A total of 269 letters were mailed, 92 of them to owners with vehicles from Group A, and 177 from Group B. We received 19 valid responses. Five of these were from Group A, and none indicated that their lead plugs had been removed. 14 of the responses were from Group B, and 5 indicated that their limiter caps had been removed or broken.

Combining these results with those from the parking lot survey gives a total of 20 vehicles from Group A and 28 vehicles from Group b. One of the Group A

vehicles had its lead plugs removed, and ten of the Group B vehicles had their limiter caps removed or broken. Table 5 lists these results, plus the number of broken or missing limiter devices as a percentage of the total group.

Table 5
Total Broken or Missing Limiter Devices

	Number in Sample	Number Disabled	Percent Disabled
Sealed Carburetors	20	1	5.0%
Conventional Carburetors	28	10	35.7%

With a 95% confidence level, a statistical analysis shows that the proportion of removed or broken limiter devices is higher for the conventional carburetors than it is for the sealed carburetor.

CONCLUSION

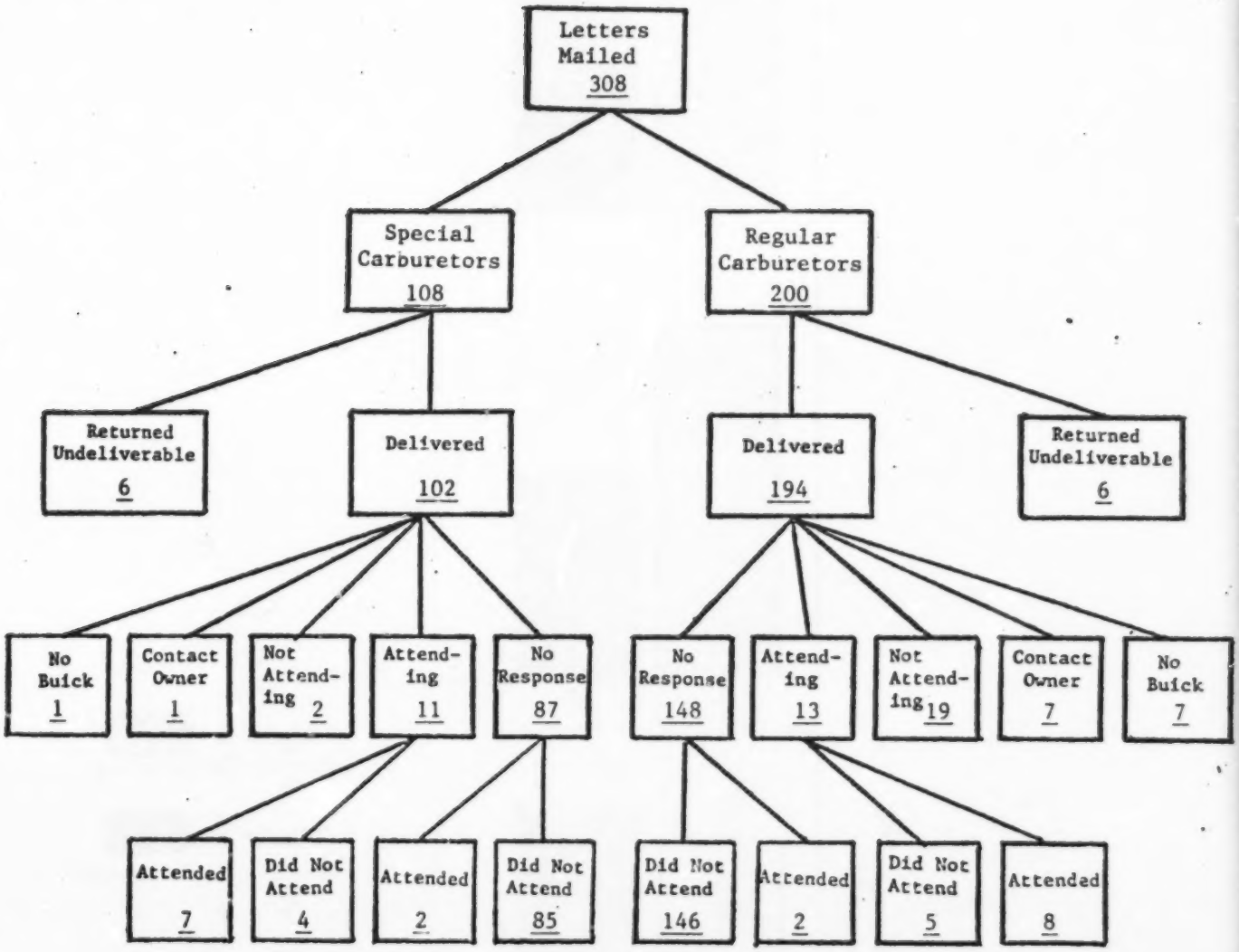
Based on the results of this study, restricting access to the idle mixture screws has proven to be effective in preventing mixture adjustments. The inability to adjust the idle mixture screws does not seem to cause engine performance problems or result in owner dissatisfaction. The average idle emissions of the vehicles with sealed carburetors are lower than the average idle emissions of those with standard carburetors. On the other hand, the results of the idle test vehicles which had their caps in place were approximately equal to the results on vehicles with sealed carburetors.

Reference

1. J. T. White, "An Evaluation of Restorative Maintenance on Exhaust Emissions from In-Use Automobiles", SAE Paper 780082, March 1978.

Figure 1

EVALUATION OF SEALED IDLE MIXTURE ADJUSTMENT ON 1977 BUICKS



RESPONSE CHART
FOR
PARKING LOT SURVEY MAILING

EVALUATION OF SEALED IDLE MIXTURE ADJUSTMENT ON 1977 BUICKS

AVERAGE FTP EMISSIONS OF GROUP A AND GROUP B

Fig. 2

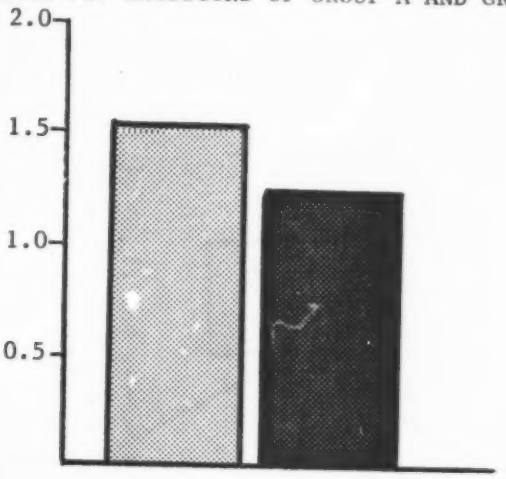


Fig.3

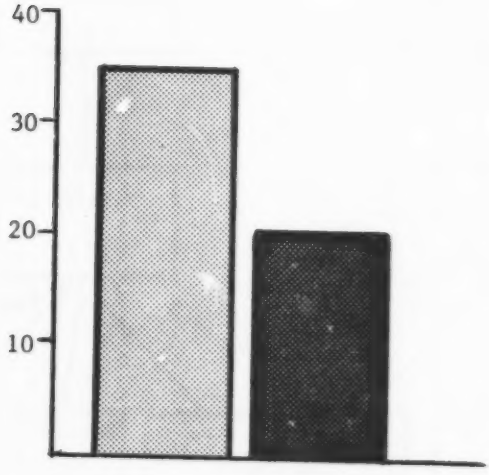
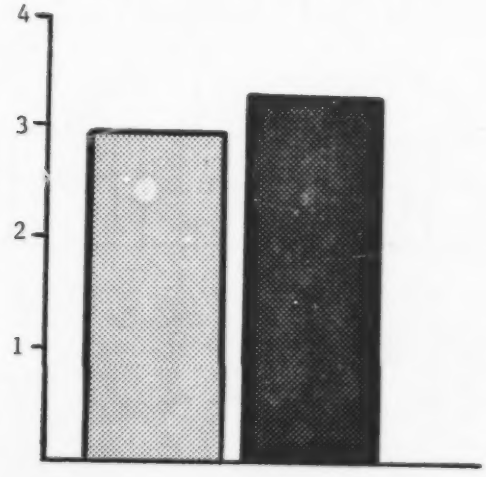


Fig.4



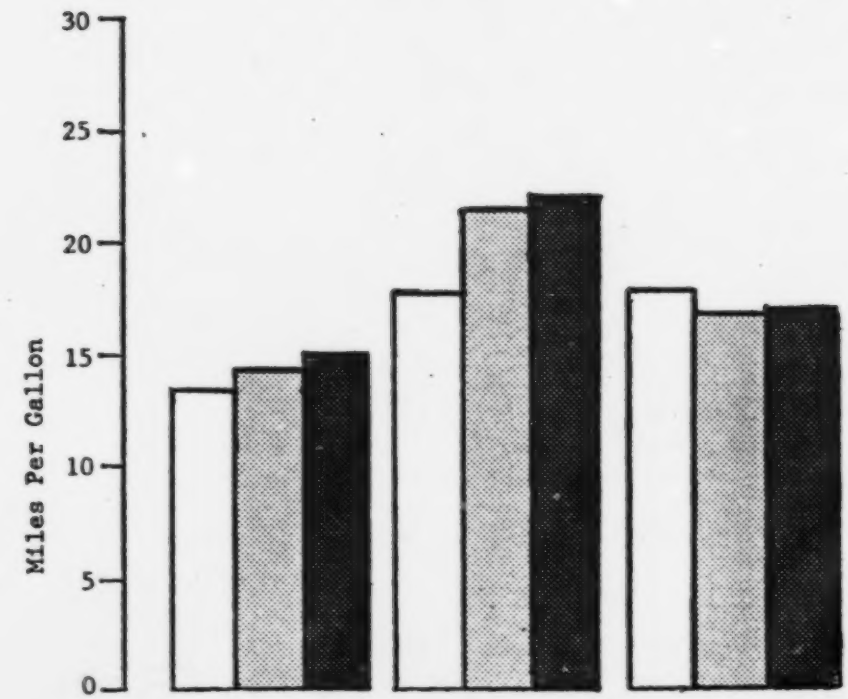
GROUP A (sealed carburetors)

GROUP B (regular carburetors)

Figure 5

EVALUATION OF SEALED IDLE MIXTURE
ADJUSTMENT ON 1977 BUICKS

Comparison of Owner Perceived MPG to
Test and Fuel Economy Guide Values



Appendix A

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR, NOISE AND RADIATION

June 17, 1980

Dear Buick Owner:

As you know, the nation's air pollution problem is a very serious matter. As a concerned citizen, you can contribute significantly toward its control and be rewarded for your cooperation.

The U.S. Environmental Protection Agency (EPA) is currently conducting a survey in the Metropolitan Detroit area which requires us to obtain information on certain passenger cars. Your car has been identified as a possible candidate for testing.

In order to determine if your car qualifies, a technician must perform a 10 minute inspection on your 1977 Buick. We will be conducting inspections at Eastland Mall on Saturday, June 28 from 10:00 a.m. through 5:00 p.m. Enclosed is a map with specific directions on where we will be located. We will have a white van with a blue EPA symbol on the side. In return for your participation in this program, you will be mailed a check for $10.00.

We are also prepared to conduct inspections at our laboratory in Ann Arbor anytime between the hours of 8 a.m. to 8 p.m. on Monday, June 23 through Friday, June 27. If this is more convenient for you than our Saturday hours, you are invited to call us at the number given below and an appointment will be made at your convenience.

Within two weeks after the inspection, you will be notified as to whether your vehicle qualifies for further testing at our laboratory in Ann Arbor. If your car does qualify and you are willing to participate further, you will be offered additional incentives which we will discuss with you then.

Enclosed is a postage-paid reply card which we ask you to complete and return at your earliest convenience. The information obtained from this inspection is for survey purposes only and will not be used in any legal action.

We are looking forward to seeing you on June 28. If you have any questions or would like further information, you may contact Karen Marschall at EPA's Motor Vehicle Emission Laboratory, 2565 Plymouth Road, Ann Arbor, MI 48105. The telephone number is (313) 668-4430 during normal business hours.

Sincerely,

John T. White

John T. White, Project Manager
Test and Evaluation Branch

Enclosure

Appendix B

Vehicle Owner Questionnaire
1977 Buick Survey

Vehicle # _____ Owner's Name _____
Address _____
_____ Zip _____
VIN _____ License Plate # _____

1. How long ago was the last tune-up (spark plugs, timing, etc.)?

   _____ approximate date ____ no tune-up

2. Who performed this tune-up?

   ____ dealer ____ garage ____ tune-up clinic ____ yourself or friend
   ____ no tune-up

3. Have you had any repairs to your vehicle for the correction of driveability problems?

   ____ yes ____ no

4. What repairs were performed on your vehicle to correct the driveability problems?

   ____ no repairs

5. Were these repairs effective in correcting the driveability problems?

   ____ yes ____ no ____ no repairs

6. How long ago were your idle mixture and speed adjusted?

   _____ approximate date _____ not adjusted

7. Do you now experience any engine performance problems with this vehicle?

   ____ yes ____ no Description: _____

8. Approximately what fuel economy do you obtain from this vehicle?

   city _____ highway _____ combined _____

Appendix C

VEHICLE NUMBER _____

A) System Inspection

		Yes	No	Comments
1. Induction System				
*a.	Is the outside air duct, air cleaner assembly, and filter intact and complete?	___	___	
b.	Is the heated air door and motor intact and complete?	___	___	
c.	Does the heated air door respond to external vacuum?	___	___	
*d.	Are the vacuum lines connected, unrestricted, and properly routed?	___	___	
2. Carb and Fuel System				
*a.	Are the plugs which seal the idle mixture screws present and unaltered?	___	___	
b.	Is the choke assembly intact and complete?	___	___	
c.	Has the fuel filler neck been altered?	___	___	
*d.	Are the vacuum lines connected, unrestricted, and properly routed?	___	___	
3. Ignition System				
*a.	Are the spark plugs, spark plug wires, and distributor cap intact and complete?	___	___	
*b.	Is the vacuum advance line connected, unrestricted, and properly routed?	___	___	
c.	Does the advance unit respond to external vacuum?	___	___	
4. EGR System				
*a.	Is the EGR valve intact and complete?	___	___	
b.	Is there a RPM drop when external vacuum is applied?	___	___	
c.	Is the vacuum line connected, unrestricted, and properly routed?	___	___	
5. EFE System				
*a.	Is the EFE valve intact and complete?	___	___	
b.	Does the valve respond when external vacuum is applied?	___	___	
*c.	Are the vacuum lines connected, unrestricted, and properly routed?	___	___	
6. PCV				
*a.	Is system intact and complete?	___	___	
b.	Does valve "rattle" when shaken?	___	___	
c.	Is the vacuum line connected, unrestricted, and properly routed?	___	___	
7. Evap				
a.	Is the system intact and complete?	___	___	

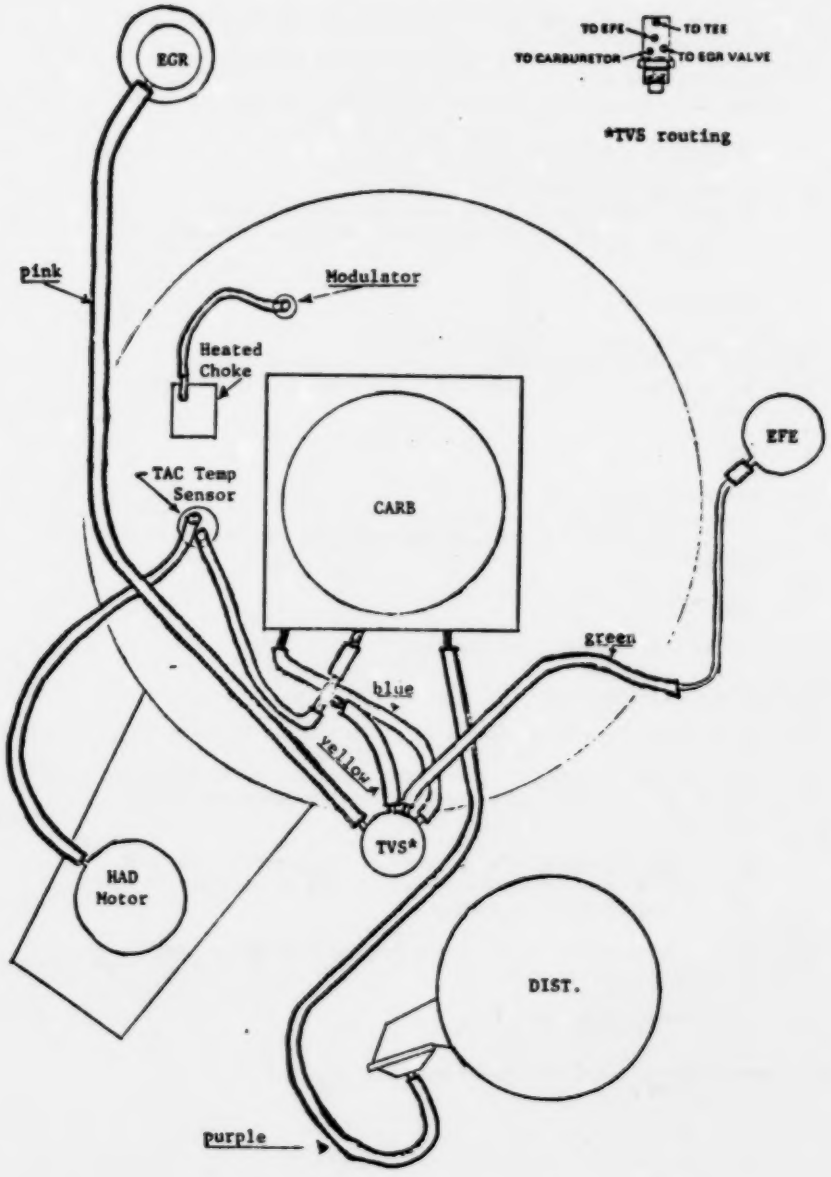
B) Adjustable Parameter Check

		Spec.	Measured
1.	Check idle speed with A/C off and transmission in drive.	550 rpm	___
2.	Propane gain procedure: Administer propane into snorkel of the air cleaner. Increase flow until maximum rpm is achieved.	50 rpm	___
3.	Check fast idle speed on high step of the cam, with the A/C off, the EGR disconnected and plugged, the air cleaner in place and the transmission in park.	1800 rpm	___
4.	Check timing at 600 rpm with the hose to the vacuum advance unit disconnected and plugged.	12°BTDC	___
5.	Check choke adjustment.	1 NR	___

* These checks should always be performed.

Appendix C
4-Speed Idle

MODE	HC(ppm)	CO(%)	RPM
IDLE(N)			
2500(N)			2500
IDLE(N)			
IDLE(D)			



Appendix D

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR, NOISE AND RADIATION

Dear Buick Owner:

We are sorry you were unable to attend our parking lot survey at the Eastland Mall on June 28. However, we are still interested in conducting a short inspection of your 1977 Buick. We can conduct these inspections here at our laboratory in Ann Arbor anytime Monday through Friday, from 8 a.m. to 5 p.m. If it is possible for you to bring your vehicle here, please contact me to schedule an appointment. For your participation in this program, you will receive a full tank of gasoline and will be mailed a check for $10.00. Enclosed is a brochure on our laboratory and a map indicating its location. Also enclosed is an EPA mileage calculator for your personal use.

If you are not able to bring your vehicle to the lab, we ask that you fill out the enclosed postcard and return it at your earliest convenience. Enclosed is a sketch of the engine compartment with figures for several types of carburetors. The carburetor on your 1977 Buick will match one of the figures. Place an "X" in the appropriate box. Also, record your car's vehicle identification number (VIN) on the card. This can be found on your registration form or on the dashboard at the base of the windshield on the driver's side. It is visible from outside the car. Once this information is recorded, you may drop the card in the mail. No postage is necessary.

If you would like to schedule an appointment at our lab, or if you need more information, you may contact me at EPA's Motor Vehicle Emission Laboratory, 2565 Plymouth Road, Ann Arbor, Michigan 48105, or call (313) 668-4430 during normal business hours.

Sincerely,

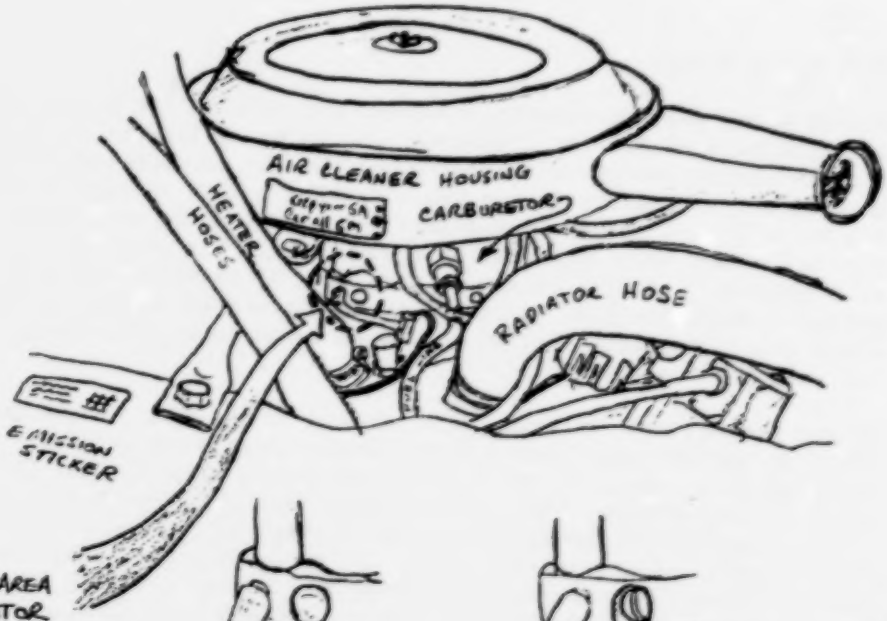
Karen E. Marshall

Karen E. Marschall, Project Officer
Test and Evaluation Branch

Appendix D

1977 BUICK

UNDERHOOD DIAGRAM



1. EXAMINE THIS AREA OF THE CARBURETOR
2. MARK THE ONE OF THESE FOUR FIGURES WHICH BEST REPRESENTS THE APPEARANCE OF THIS AREA

FIGURE 1. ☐

FIGURE 2. ☐

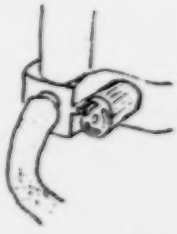


FIGURE 3. ☐

FIGURE 4. ☐

Appendix D

EVALUATION OF SEALED IDLE MIXTURE ADJUSTMENT ON 1977 BUICKS

Mail Survey Reply Card

I have examined my car and have determined that the figure which most closely resembles the appearance of the carburetor is (check one):

☐ Figure 1 ☐ Figure 2

☐ Figure 3 ☐ Figure 4

Vehicle Identification Number (VIN) _____

Name _____

Street _____

City/State _____ Zip/ _____

Telephone _____

EPA

United States
Environmental Protection
Agency

Official Business
Penalty for Private Use
$300

Postage and
Fees Paid
Environmental
Protection
Agency
EPA 335

U.S. MAIL

Karen Marschall
EPA, ECTD, TEB-20
2565 Plymouth Rd.
Ann Arbor, MI 48105

EPA FORM 1320-5A (2-79)

Appendix E

EVALUATION OF SEALED IDLE MIXTURE ADJUSTMENT ON 1977 BUICKS

PARKING LOT SURVEY RESULTS

Four-speed Idle

Veh.#	Odom	Group	Temp?	RPM	HC(ppm)	CO(%)	RPM	HC	CO	RPM	HC	CO	RPM	HC	CO	Tune up?	Comments
01	24872	B	No	880	1000	.08	2500	430	.10	880	800	.06	650	100	.02	no	
02	43919	B	No	820	30	.03	2500	12	.67	1020	30	.02	690	22	.03	no	
05	27379	B	No	870	175	.12	2500	70	1.50	850	155	.11	620	150	.07	yes	no EGR mvmt
11	30774	B	No	970	77	.01	2500	19	.01	878	93	.01	660	44	.01	yes	
13	48201	B	No	977	244	.22	2500	82	1.23	979	63	.08	680	43	.02	yes	no EGR mvmt
17	38064	B	No	750	25	.01	2500	80	2.70	770	20	.05	560	14	.02	yes	no EGR mvmt
19	43085	B	No	780	430	.90	2500	90	2.65	810	475	.70	600	230	.53	yes	no EGR mvmt
28	35242	B	No	745	96	0.0	2500	9	0.0	805	80	0.0	591	37	0.0	yes	
29	36643	B	No	800	221	0.0	2500	19	.03	800	117	0.0	650	44	0.0	no	
12	40908	B	Yes	850	107	.01	2500	52	1.05	890	55	.54	620	54	.01	yes	
15	65746	B	Yes	610	277	2.4	2500	85	2.81	630	265	2.83	470	259	2.69	yes	
16	34122	B	Yes	756	149	.02	2500	54	.98	820	250	.07	600	9	.01	yes	EGR questionable
21	46708	B	Yes	980	70	.01	2500	30	.02	1000	40	.01	650	25	.01	yes	vacuum line repaired
23	56900	B	Yes	825	490	5.2	2500	80	1.1	825	420	5.0	600	260	4.9	yes	HAD line disconnected
03	16233	A	No	850	65	.02	2500	40	.40	800	48	.02	640	30	.01	no	
04	24141	A	No	700	300	.02	2500	20	.20	690	250	.02	400	75	.02	yes	body work no EGR mvmt
06	41076	A	No	790	100	.02	2500	19	.30	780	100	.03	600	20	.02	yes	no EGR mvmt
07	38109	A	No	650	100	.07	2500	30	.30	520	150	.07	520	90	.06	?	no EGR mvmt
08	36465	A	No	500	50	.01	2500	40	.32	640	30	.03	520	9	.01	?	
09	33267	A	No	730	120	.01	2500	15	.02	750	137	.02	670	50	.01	no	new pistons no EGR mvmt
10	48937	A	No	890	71	.03	2500	129	6.50	960	60	.06	650	40	.02	no	dirty air cleaner no EGR mvmt
14	9499	A	No	760	207	.10	2500	79	2.20	800	174	.14	600	163	.10	no	
18	26798	A	No	830	13	.03	2500	80	2.85	800	16	.04	610	10	.02	yes	no EGR mvmt
22	61000	A	No	700	180	.02	2500	30	.02	720	220	.02	520	100	.01	yes	no EGR mvmt
24	47392	A	No	890	160	1.5	2500	45	.85	900	120	.80	640	140	.89	yes	
25	61831	A	No	890	186	.02	2500	0.0	.05	930	152	.01	640	51	.01	yes	filler neck punched out
26	21981	A	No	754	37	0.0	2500	40	1.11	768	29	0.0	572	15	0.0	no	
27	44470	A	No	620	35	.02	2500	55	.90	740	40	.02	560	36	.02	yes	
20	65445	A	Yes	825	190	.02	2500	35	.05	825	160	.02	625	50	.01	yes	choke replaced

Appendix F

Vehicle Owner Questionnaire Replies

Vehicle No.	Odometer	Group	How long since last tune-up (months)?	Who performed tune-up?	Had repairs for driveability problems?	What repairs?	Repairs effective?	How long since idle mixture and speed adjusted (months)?	Have engine performance problems now?	Fuel Economy		
										City	Highway	Combined
3	A	16233	never	-	Yes	B.	Yes	unknown	No	unknown	unknown	unknown
4	A	24141	24	dealer	No	-	-	not adj.	No	unknown	unknown	unknown
6	A	41076	6	dealer	No	-	-	1	No	14	18	unknown
7	A	38109	unknown	unknown	No	-	-	unknown	No	unknown	unknown	unknown
8	A	36465	unknown	unknown	No	-	-	12	No	13	unknown	unknown
9	A	33267	never	-	Yes	P.	Yes	not adj.	No	17	20	19
10	A	48937	never	-	Yes	L.	Yes	not adj.	No	11	unknown	unknown
14	A	9499	never	-	No	-	-	not adj.	No	unknown	20	18
18	A	26798	18	dealer	No	-	-	unknown	Yes-E.N.	14	21	unknown
20	A	65443	1	dealer	Yes	Ch.	No	1	Yes-D.	unknown	unknown	18
22	A	61000	7	dealer	No	-	-	not adj.	Yes	unknown	17	unknown
24	A	47392	1	owner	No	-	-	not adj.	No	unknown	unknown	19
25	A	61831	1	clinic	No	-	-	not adj.	Yes-L.	16	unknown	unknown
26	A	21981	never	-	No	-	-	not adj.	No	unknown	20	unknown
27	A	44470	8	dealer	Yes	Sp.	Yes	unknown	No	unknown	unknown	unknown
1	B	24872	never	-	No	-	-	not adj.	No	13	17	unknown
2	B	45919	never	-	No	-	-	not adj.	Yes-E.N.	10	12	unknown
5	B	27379	6	dealer	No	-	-	not adj.	No	13	19	unknown
11	B	30744	7	owner	No	-	-	not adj.	No	unknown	unknown	17
12	B	40908	9	owner	No	-	-	not adj.	No	unknown	unknown	15.5
13	B	48201	7	owner	No	-	-	not adj.	No	15.7	19	unknown
15	B	65746	6	clinic	No	-	-	not adj.	No	14.5	18	unknown
16	B	34122	7	dealer	No	-	-	not adj.	No	15	20	unknown
17	B	38064	10	dealer	Yes	Br.	Yes	not adj.	Yes-E.N.	unknown	unknown	unknown
19	B	43085	9	dealer	No	-	-	unknown	No	unknown	20	unknown
21	B	46708	1	owner	Yes	V.L.	No	1	Yes-D.	unknown	unknown	unknown
23	B	56900	8	dealer	No	-	-	8	Yes-E.M.	13	17	15
28	B	35242	1	garage	No	-	-	not adj.	No	unknown	15	unknown
29	B	36643	never	unknown	No	-	-	not adj.	No	15	20	unknown

B. - Belt Replaced
P. - Pistons Replaced
L. - Lifters Replaced
Ch. - Choke Replaced
Sp. - Springs Replaced
Br. - Brake Shoes Replaced
V.L. - Vacuum Line Repaired
E.N. - Engine Noise
D. - Driveability Problems
E.M. - Cold Start Engine Miss

Appendix G

Evaluation of Sealed Idle Mixture Adjustment on 1977 Buicks
MVEL Short Cycle Test Results

		Four Speed Idle								Loaded Two-mode			
		I(N)		2500		I(N)		I(D)		Loaded		I(N)	
Veh. #	Group	HC	CO	HC	CO	HC	CO	HC	CO	HC	CO	HC	CO
1	A	40	.01	105	3.60	50	.01	30	.01	26	.03	92	.02
2	A	380	.80	50	1.40	380	.85	195	.65	95	1.75	390	.38
		360	.17	50	1.20	360	.24	190	.75	105	1.25	360	.25
3	A	10	.03	10	.04	20	.03	10	.03	20	.09	20	.03
		40	0	30	.001	50	.001	30	.001	50	.15	40	.001
4	A	20	.02	10	.02	20	.02	10	.02	20	.03	30	.02
		30	.02	30	.02	35	.02	25	.02	40	.03	60	.03
5	A	80	.02	20	.02	80	.02	20	.02	20	.02	100	.02
		60	.02	0	.02	50	.02	20	.02	20	.02	80	.02
6	B	45	.03	103	4.80	51	.03	19	.01	40	.10	65	.01
		100	.04	100	4.00	80	.01	30	.01	95	1.40	60	.01
7	B	170	.70	10	.05	200	1.30	160	1.10	110	.95	250	.30
		220	.03	20	.01	250	.08	155	.08	98	.07	205	1.2
8	B	10	.01	0	.01	20	.01	0	.01	0	.01	60	.01
		20	.02	20	.02	20	.02	10	.02	10	.03	30	.02
9	B	600	2.00	20	.02	280	6.40	260	6.20	80	.20	300	6.00
		350	2.75	40	.25	350	2.60	290	3.00	95	.25	300	3.10
10	B	130	1.20	70	1.25	140	1.00	170	1.00	120	.75	140	1.30
		121	1.10	20	.02	120	1.00	140	.80	100	.70	125	1.00
11	B	180	1.60	50	1.10	240	2.20	215	2.05	120	1.90	245	2.35
		110	1.40	40	.04	130	1.90	220	2.00	130	1.00	230	1.90
12	B	55	.02	60	.02	60	.02	55	.02	60	.02	65	.02
		45	.04	50	.04	50	.04	50	.04	55	.04	60	.04
13	B	60	.02	60	.05	65	.03	50	.02	60	.20	60	.02
		50	.04	70	1.20	50	.04	45	.04	120	1.40	60	.04

Appendix G

Evaluation of Sealed Idle Mixture Adjustment on 1977 Buicks

Parking Lot Results

Veh.#	Group	Tamp?	Idle (N) HC	Idle (N) CO	2500 HC	2500 CO	Idle(N) HC	Idle(N) CO	Idle(D) HC	Idle(D) CO	Odom
1	A	N	71	.03	129	6.50	60	.06	40	.02	50848
2	A	N	50	.01	40	.32	30	.03	9	.01	38407
3	A	N	100	.02	19	.30	100	.03	20	.02	42509
4	A	N	100	.07	30	.30	150	.07	90	.06	40077
5	A	Y	190	.02	35	.05	160	.02	50	.01	66474
6	B	N	1000	.08	430	.10	800	.06	100	.02	25342
7	B	N	430	.90	90	2.65	475	.70	230	.53	44652
8	B	Y	70	.01	30	.02	40	.01	25	.01	47030
9	B	Y	277	2.47	85	2.81	265	2.83	259	2.69	72173
10	B	N	244	.22	82	1.23	63	.08	43	.02	50809
11	B	Y	175	.12	70	1.50	155	.11	150	.07	29842
12	B	N	96	0.0	9	0.0	80	0.0	37	0.0	35852
13	B	N	25	.01	80	2.70	20	.05	14	.02	41040

MVEL Results

HC(g/m)	CO(g/m)	NOx(g/m)	FTP MPG	HFET MPG	Comments
2.76	113.18	1.86	12.9	15.2	no EGR mvmt
2.21	86.08	1.65	13.9	19.1	dirty air cleaner
2.23	33.35	1.30	14.6	21.2	
1.99	29.93	1.32	14.3	21.5	
.89	12.48	4.43	15.3	22.8	no EGR mvmt
.81	14.16	4.06	15.3	22.8	
.75	8.83	5.39	15.5	22.8	no EGR mvmt
.73	8.43	5.34	15.7	23.0	timing-3°
1.47	21.95	2.13	13.7	21.2	Choke 3 NR; EFE Stuck
1.54	24.21	2.36	13.2	21.3	HAD line plugged
.40	6.55	4.58	16.5	24.2	no EGR mvmt
.43	6.88	4.60	16.2	24.1	
1.72	21.58	4.36	15.6	23.0	no EGR mvmt
1.91	23.27	4.56	15.3	22.6	
.51	5.59	1.99	13.8	21.4	
.51	4.48	2.03	14.2	21.6	
2.32	39.43	1.24	14.2	21.0	
2.04	42.12	1.31	14.2	21.2	
1.30	20.02	4.97	14.5	22.4	
1.31	19.14	4.94	14.4	22.0	No EGR mvmt
2.44	49.15	4.20	14.9	22.6	No EGR mvmt
2.21	37.59	4.18	15.1	23.0	
.54	10.80	1.71	13.6	20.1	
.52	10.03	1.63	13.6	20.3	
.76	15.22	3.72	15.7	23.3	No EGR mvmt
.87	17.21	3.65	15.6	23.6	

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